# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

Since Terzaghi formulated his consolidation theory in 1923, many extensions had been made continuously to solve many of the unrealistic assumptions made in original theory. Today, consolidation theory had reached an advanced development that solutions are available for most practical problems. Some researcher refines Terzaghi's theory by solving a more generalized form of the differential equation of consolidation (Sheahan and Watters, 1997). Others established new governing consolidation equations based on realistic stress-strain-time models to yield compression-time and pore pressure-time relationships (Znidarcic and Schiffman, 1981). Numerous techniques to measure the compressibility of the soil were introduced after the conventional oedometer test is standardized. These new techniques include constant rate of strain consolidation test, constant rate of load consolidation test, constant pore pressure gradient, constant pressure ratio, restricted flow consolidation and back pressure control.

Constant rate of strain consolidation test is one of the new developments suggested by many researchers to suit the market nowadays. Constant rate of strain consolidation test can reduce the time needed for consolidation test using standard oedometer test from almost two weeks time to few hours. The constant rate of strain

consolidation test also has been used as the standard consolidation test in Sweden, Norway, The United States and France.

The Criteria acceptance for the constant rate of strain consolidation test is the objective of the research because the CRS is not a standard consolidation test in Malaysia. The results of the constant rate of strain consolidation test (CRS) depends on the strain rate used in CRS test, so it is important to compare the results for the different strain rate of CRS test with the conventional oedometer test. The criteria of acceptance for the CRS test were developed for future improvements on consolidation test.

Previous researcher suggested few criteria to accept the CRS test result upon comparing the CRS test results with the conventional oedometer. These criteria of the acceptance for the CRS test were based on the comparison of void ratio curve (e against effective stress), coefficient of consolidation ($c_v$), normalized strain rate ($\beta$) and ratio of excess pore pressure to applied total stress ($u/\sigma_v$).

## 1.2 Statement of the Problem

Since 1950's, the standard compressibility test has been used to measure the soil compression characteristic is the one-dimensional Compression Test (Oedometer Test) based on Terzaghi theory. This one-dimensional oedometer test is one of the simplest forms of soil loading test which the soil sample is placed in a stiff metal cylinder so that radial strains equal to zero. Porous discs at the top and bottom to provide drainage of excess pore water (Figure 1.1).

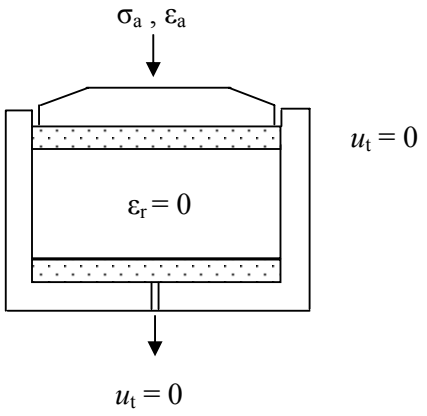


Figure 1.1: Conventional Oedometer.

Conventional oedometer test based on Terzaghi's theory is a step loading tests which took around two weeks for one complete test with loading and unloading stages. The test is also limited to low to medium loading for a sample size of 75 mm diameter. Beside that, pore pressure at the bottom of the soil sample is not usually measured.

Many researchers have introduced other methods to measure the compressibility characteristics of the soil. One of the new developments is the CRS test. Through the CRS test, the testing time for a completed test can be reduced from around two weeks to few hours. The compression test can be conducted until a very high pressure.

The main problem of the CRS test is to determine the proper strain rate used in the test. The selection of the test rate is still a major hurdle in CRS test although many researchers had done various studies on this. Many recommendations had been offered by researchers (Lee, Choa, Lee and Quek, 1993) for the selection of test rate but these recommendations are empirical and vary with clay type.

This research is aimed at finding a criterion on the strain rate used in CRS test for various types of clay obtained in Johor. Modifications on the available strain rate selection method for CRS test is recommended.

## 1.3 Objectives

The following objectives are set forth to achieve the aim of the research:

i. To develop consolidation equipment that could be used to run rapid consolidation using constant rate of strain consolidation method.

ii. To compare the result of the compression characteristic of the soil, coefficient of consolidation ($c_v$) and compression index ($c_c$) obtained from CRS test to the results of conventional oedometer test.

ii. To establish the new criteria of acceptance for Constant Rate of Strain consolidation test.

## 1.4 Scope of the Study

The soil samples for the study are remoulded from disturbed samples obtained from different sites in Malaysia. The interpretation of the research of the study is limited to:

i. Disturbed samples are collected from Kluang, Gemas and Air Papan, Johor (Figure 1.2). Kaolin soil was used as the control sample for the study.

ii. The specimens used for the study is remoulded sample. In the case all the disturbed soil samples were dried and grinded into powder and remoulded from slurry under 100, 200 and 300 kPa pre-consolidation pressure using self made remoulded sampler equipment.

iii Conventional oedometer test and the Constant Rate of Strain consolidation test will be conducted to a maximum of 8.5 kN and 1100 kPa vertical pressure respectively.

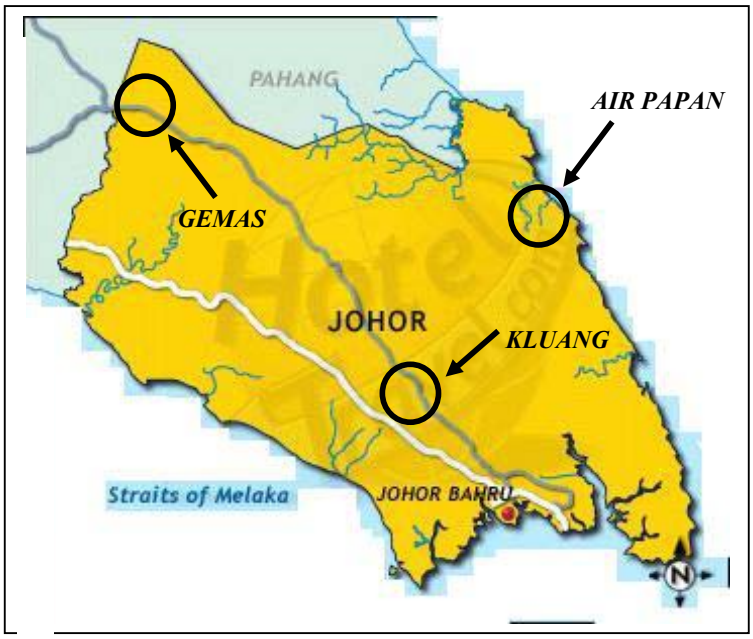


Figure 1.2: Study Area of the Research

## 1.5 Significant of Research

The main purpose of this study is to give recommendations on the testing rate selection which is still a major hurdle in CRS test as well as to establish new criteria of acceptance. Comparisons on the compression characteristics of soil based on oedometer and CRS test were made to establish the criteria of acceptance. With the recommended new criteria on the strain rate selection, geotechnical engineers can easily run the consolidation test for all cohesive soil in a short time. It can reduce the time for construction to wait the results on the soil compressibility characteristics. Beside that, CRS test can achieve higher effective pressure which is the disadvantage of the standard oedometer test. Geotechnical engineers can use this test as the alternative of the on site load test.